Minutes from

FASSET/BIOMASS Workshop

Stockholm

30–31 October 2001

FASSET
Framework for ASSessment
of Environmental impacT

Foreword

The International Atomic Energy Agency (IAEA) has co-ordinated the BIOMASS (Biosphere Modelling and Assessment) project, aimed to develop and apply a methodology for defining biospheres for practical radiological assessments of releases from repositories for radioactive waste. The EC funded FASSET (Framework for Assessment of Environmental Impact) project aims at developing an assessment methodology for estimating impact of ionising radiation on biota and ecosystems. It is obvious that the two projects address related problems and that methodology developed in BIOMASS could be useful for, and could be further elaborated by, the FASSET project.

In order to explore how FASSET can take on board experiences gained within BIOMASS, a workshop was organised 30–31 October 2001 in Stockholm, Sweden. This report contains the minutes from this workshop.

Carl-Magnus Larsson
Co-ordinator of FASSET

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APPENDICES

1. Introduction

Carl-Magnus Larsson, FASSET co-ordinator

Participants were welcomed by Carl-Magnus Larsson (SSI), host of the meeting and co-ordinator of the FASSET project.

The main purpose of the meeting was to ensure that the conclusions and methods developed within BIOMASS and related projects are effectively used within FASSET. A secondary objective was to promote continuing interaction on methodological and technical developments among participating organisations.

Concerning BIOMASS, thanks were given to the IAEA, to the sponsors of the various Working Groups and to the authors of the Technical Documents and Working Material for making the information readily available to the FASSET participants.

An overview of the BIOMASS Programme was presented, and it was suggested that Theme 1, Reference Biospheres Methodology, and the Assessment Context within it, are the most relevant aspects of BIOMASS to carry forward into the FASSET Project. However, the question was also asked as to whether there are any other conclusions and methodology components from BIOMASS that can be incorporated into the FASSET programme.

The IAEA is considering the possibility of setting up a follow up programme to BIOMASS. This is expected to be initiated during the second half of 2002. It is possible that BIOMASS output and a description of the new programme will be presented at the Conference on Radiation and the Environment in Monaco in September 2002. IAEA is interested in suggestions from FASSET participants and others regarding the possible technical programme for a BIOMASS follow up. The process will involve e-mail consultation with relevant parties.

Several ideas have already been considered for inclusion and development in a second programme:

- Assessment database (more or better information needed) – natural and semi-natural ecosystems, incorporating work already completed on forest systems;
- Biosphere change;
- Inter-comparison of models;
- Non-radioactive pollutants;
- Impact assessment on non-human species;
- Human intrusion;
- Methodologies for developing groundwater releases;
- Doses to species other than man.

Because of the relevance to FASSET, a final consensus statement and guiding principles were produced from the recent conference on Environmental Ethics and Philosophy Consensus (Norway, 22–25 October 2001). However it must be borne in mind that the views and agreements reached were personal opinions, not representative of countries or organisations. See appendix 2.

2. Outline of FASSET, Framework for Assessment of Environmental Impact

Carl-Magnus Larsson, FASSET co-ordinator

All deliverables and the technical annex are available to the public, via FASSET's website (www.fasset.org).

The purpose of the programme is to develop a framework for environmental assessments with emphasis on biota and ecosystems. There are a number of environmental aspects to consider, but it is also important to remember the relevant level of simplification required.

Environmental assessment methodologies have been discussed for some time, but FASSET will be more focussed on assessments of the impacts of radiation on European ecosystems. The programme uses a framework that includes:

- Problem formulation (e.g. source characterisation, timeframes, the object for protection);
- Risk assessment (e.g. risk characterisation, and effects and exposure analysis);
- Risk management (to be taken by individual regulatory authorities).

Ecological risk assessment and management		
Problem formulation	**Risk assessment**	**Risk management**
Description and definition of assessment context Purpose Philosophy Source characterisation and hazard identification Spatial and temporal considerations Identification of the object of protection Identification of what is to be measured/predicted in order to determine the degree of protection Treatment of background	**Methodologies and results relevant to** Exposure analysis Effects analysis Risk characterisation and consequence analysis	**Prevention, mitigation and elimination of consequences**

Figure 1

Phases of ecological risk assessment and management. FASSET will only tackle the first two phases because the project is not designed to be a regulatory tool.

2.1 Deliverables of FASSET

There will be six deliverables:

Deliverable 1 Ecosystem description and ecosystem approach to identification of target organisms (12 month time scale, to be published in the next few weeks);

Deliverable 2 Generic framework incorporating elements of existing programmes (24 month time scale);

Deliverable 3 Report on dosimetry, doses in relation to contamination and background (30 month time scale);

Deliverable 4 Report on radiation effects (30 month time scale);

Deliverable 5 Handbook for the initial part of the environmental radiation impact assessment (time scale 36 months);

Deliverable 6 Final systems report (time scale 36 months).

The conclusions from this meeting will feed into Deliverable 2 as part of WP 4 (co-ordinated by SSI).

The first deliverable will discuss ecosystem characterisation. This includes identification of representative reference organisms for certain ecosystems, based primarily on radioecological criteria. They can be used as indicators of environmental dosimetry, exposure pathways, and environmental effects. They also can be used as a starting point for more site-specific investigations. Expert judgement was used to identify reference organisms because there are no mathematical models to choose the organisms more specifically.

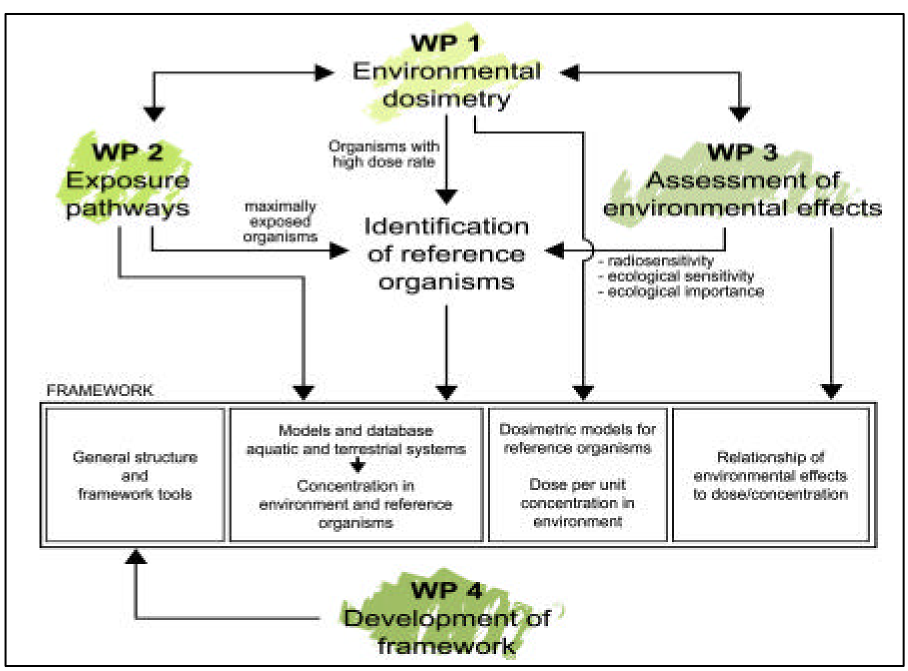


Figure 2

Contribution of FASSET work packages to the identification of reference organisms, and to generation of the frame-work.

WP3 will also gather literature data on biological effects with ecological significance: morbidity, mortality, reproductive success, scorable cytogenetic effects (mutations/mutation rate). All these categories overlap, and the information will be used as input to the Radiation Effects Database, following a structure developed by the UK Environment Agency. Dose response curves are to be produced to support WP 4 final framework.

The database will receive input from several sources; therefore a quality assurance check will be completed before final circulation. It is probable that a number of gaps will be identified that may be used to guide future research programmes.

3. BIOMASS (Biosphere Modelling and Assessment) presentations

3.1 Assessment context

Graham Smith, Enviros Quantisci

A presentation of the key assessment context issues of potential relevance to FASSET was provided. The main points arising from discussion were:

The scope and objectives of the project, and any fundamental questions need to be addressed at the beginning of the project, not at the end. While this is obvious, some assessment projects have not been managed this way.

The fundamental questions help address the context for the assessment, and includes:

- What is the purpose of the project? The end-users and the endpoints (such as what are we trying to protect?) need to be taken into account at this stage.
- How should uncertainties be approached, and what assumptions should be made?
- What site or system is to be investigated? Is a generic reference biosphere truly representative of what is being considered?
- What are the source terms and modelling interfaces? What radionuclides and systems are of interest, and what effect is already present? Are humans considered a part of nature? Are human practices regarded as natural?
- What are the best timeframes to discuss? Often a trade off is needed between short and long term timeframes. The Lepse (Russian vessel used for storage for spent nuclear fuel) risk-timeframe graph was discussed. This illustrates that some action is necessary to avoid serious long term risks, but that viable options to reduce long term risks may, in the short term, increase risks above the current level.
- What assumptions does society make? Do humans affect the future or change these systems? The answer is more than a scientific issue.

3.2 System identification and justification of biosphere system

Marianne Calvez, ANDRA – DS/BE

A presentation of the key system identification and justification issues of potential relevance to FASSET was provided. The main points arising from discussion were:

A definition of a Biosphere System and description of the specific components within a system were provided. All classifications and definitions used in BIOMASS are available in the IAEA BIOMASS documentation. All the information has been agreed internationally and can be used in future biosphere system projects.

The BIOMASS endpoint was protection of human health from radiation, if protection of the environment was the main endpoint, the system would be more complex. Biota was considered in BIOMASS reference biosphere systems, but only in the context of their effect on human health (i.e. through exposure pathways).

In some instances, the biosphere system may already be pre-defined by existing legislation or guidance. If the system is not already identified, the BIOMASS methodology (described by these presentations) provides a good starting point. The methodology includes explanation of how to identify:

- The primary components;
- The mechanisms that cause change (internal and external driving mechanisms responsible for environmental change in the system);
- The potential impacts (described in an interaction matrix);
- Possible future events and processes (FEPs).

Once the system has been identified, you can consider what approach to use: sequential (considers change over time in a continuous manner) or non-sequential (independent).

Justification is required throughout the system identification process to ensure that the system description will stand up to scrutiny. Once identified and justified, the system can be described in full.

3.3 System description and model development

Paloma Pinedo, CIEMAT

A presentation of the key system description and model development issues of potential relevance to FASSET was provided. The main points arising from discussion were:

The system description information and details of the potentially exposed groups were the two main inputs for development of the BIOMASS models. It is important to define the level of human interaction and the level of control the potentially exposed groups have on the system because behaviour and exposure can alter the system.

It is important and useful to review and develop a systematic audit trail for quality assurance reasons, and to highlight what components are included or excluded from the system description and why. The components and their characteristics are defined in generic tables, e.g. climate and atmosphere, water bodies, ecosystem community and human community. Once the components are classified, the relationships between the principal components can be described, including the exposure pathways.

The above information feeds into the development of a conceptual model, which now includes radionuclides, as well as interactions and important FEPs. A complex interaction matrix, using actual data can now be created, therefore at the same time, the data sources need to be identified. If no data is available, average data for typical components and relational tables are included.

3.4 Application of data

Santucci, presented by Graham Smith, Enviros Quantisci

A presentation of the key application of data issues of potential relevance to FASSET was provided. The main points arising from discussion were:

Information and data influence all aspects of the methodology and therefore cannot be considered in a linear fashion. Models and data have a strong relationship, which is dependent on the quality of the data. It is important to have consistency within the choices of data, from the assessment context through to the development of the model. However, data are often supplied from a number of sources, which can lead to uncertainty in the results. There are three types of data sources:

- Data from reliable and traceable sources;
- Well-known local data;
- Poorly characterised data.

If the biosphere system being assessed is a site-specific situation, data will be key issue. If data is missing or incorrect, it is important to investigate ways of identifying the correct data. This can be done, for example, through a formal elicitation process, such as an expert group.

A data protocol, consisting of an introduction, structuring, conditioning, encoding and adoption of a formal output format, should be documented for transparency and traceability reasons. Creation of a data protocol can be expensive and resource intensive, but can be simplified.

4. Other EC projects of interest

4.1 BIOCLIM

Marianne Calvez, ANDRA – DS/BE

A presentation of the key BIOCLIM issues of potential relevance to FASSET was provided. The main points arising from discussion were:

BIOCLIM began in 2000 and will be completed in late 2003, and is a project within the EC 5th Framework Programme. The project aim is to model sequential biosphere systems due to climate change that may impact on radioactive waste disposal.

A long timeframe is considered, during which there will be climatic changes that may affect biosphere evolution. During the 1990's the international community was mainly focussed on present day temperate biospheres, therefore BIOCLIM was developed to provide a sequential approach to biosphere assessment as an alternative to BIOMASS.

Currently available climate and vegetation (or biome) models are used to assess biosphere change and the possible effects on radioactive waste repositories, but the models are only illustrative (not prescriptive) of future change. The BIOCLIM project will use the BIOMASS methodology within WP 4 to determine biosphere systems. Either discrete strategies, i.e. climate change for specific episodes, or a continuous strategy using climatic data for a longer period of time are developed within WP 2 and 3 to identify the future evolution of climate and vegetation. The objective is to integrate the model results into site-specific performance assessments.

Waste management agencies, regulators, research institutes and consultants from a number of countries are involved. There are five work packages:

- WP 1 – Consolidation of needs (almost completed);
- WP 2 – Hierarchical strategy (end May 2003);
- WP 3 – Integrated strategy (end May 2003);
- WP 4 – Biosphere system description (end August 2003);
- WP 5 – Final seminar in October 2003.

The outputs from the work packages will consist of 13 deliverables that will allow justification and identification of possible future systems for both snapshot episodes, and continuous evolution.

Initially it is not intended in BIOCLIM to provide impact calculation. However, suggestions for further work have been made. The suggestions include examining the potential radiological exposure to humans and the potential impact on non-human biota (following FASSET methodology).

A product of another study conducted by ANDRA that is of relevance to FASSET, is a paper written by ANDRA discussing 'a model for evaluating radiological impacts on organisms other than man for use in post-closure assessments of geological repositories for radioactive wastes'. This paper will be submitted to the Journal of Radiological Protection in December 2001.

Details of the BIOCLIM project can be found on the website www.andra.fr/bioclim

4.2 BIOMOSA

Gerhard Pröhl, GSF

A presentation of the key BIOMOSA issues of potential relevance to FASSET was provided. The main points arising from discussion were:

BIOMOSA, another European Union funded project, will begin in November or December 2001, and will be completed in late 2003. The project will address the application of BIOMASS methodology for setting up biosphere models in safety assessments of radioactive waste disposals.

The methodology will be applied to real sites within Europe that have different climatic features. It is hoped that the biosphere models will be able to predict endpoints that are defined in the assessment context. A generic model will also be made to represent a larger region of Europe. Future climate change will be an important component; therefore input from BIOCLIM will be used. The specific sites, and the two approaches (site-specific and generic modelling) will be compared with the aim of answering the question, *how specific does a model have to be to address the endpoints of radioactive waste disposal?*

4.3 EA study of impacts on wildlife

Irene Gize, Environment Agency

A presentation of the EA study on the impacts of ionising radiation on wildlife and the key issues of potential relevance to FASSET was provided. The main points arising from discussion were:

The aims and objectives of this study are different to those of FASSET, however the methodology and data required followed the FASSET approach. Similar components are used in both projects, for example:

- The ecosystems modelled;
- The radionuclides studied;
- The choice of reference organisms;
- The level of protection required;
- The umbrella effects considered.

The study investigated dose rate calculations and impact assessment of ionising radiation on target organisms. To do this, the assessor's requirements were: a radionuclide source, exposure pathways and ecological parameters. Many assumptions were then made about total absorbed dose and compared with known radiological effects. The result was a comprehensive set of spreadsheets that are able to calculate concentrations in different organisms within an ecosystem.

The methodology used in this study was compared to the BIOMASS methodology, and the ecosystems involved were based on the UK. However, they are somewhat generic and are therefore applicable to other countries. The study is to be expanded to consider the impact of radioactive discharges from non-nuclear licensed sites (small users). The methodology in the continuation programme will be applied as a regulatory tool, and may change with input from FASSET.

The EA approach described has been applied to real sites and included in the Magnox, Sellafield and Devonport (a non-nuclear licensed site) consultations.

4.4 EPIC, Environmental Protection from Ionising Contaminants in the Arctic

Carl-Magnus Larsson, FASSET co-ordinator

This project has a similar approach to FASSET, but it is site-specific focused on the Arctic environment. The project will be completed in mid-2003.

4.5 EPICENTRE

Graham Smith, Enviros Quantisci

This is a further EC project about the application and implementation of Environmental Management Systems.

4.6 SKB consideration of biosphere

Ulrik Kautsky, SKB

A presentation of the key work areas of SKB that include biosphere assessment was provided. The main points arising from discussion were:

SKB include biosphere assessment in a number of projects, for example:

- The study of the LLW/ILW site at Forsmark;
- Carbon modelling including many pathways, e.g. decomposition, water flow, which can be applied to other radionuclides;
- Site suitability program for deep geological disposal;
- Biosphere and interaction matrix studies, considering the ecosystem and physical characteristics of the system.

SKB will publish in English in December 2001 the last six year research review.

5. Summary of discussion groups output

Two discussion groups were formed to consider integration of the BIOMASS methodology (information from Annex A–D) into FASSET:

Group 1

How can we better define the FASSET tasks taking into account the BIOMASS methodology?

Group 2

How would the BIOMASS address the FASSET methodology?

5.1 How can we better define the FASSET tasks taking into account the BIOMASS methodology? – Assessment context (Group 1)

5.1.1 Purpose

The implications of different purposes, e.g. application to different types of environmental releases, compliance with a limit, or determination of the actual impact, need to be considered.

Do the FASSET objectives adequately specify what is to be assessed and why?

No, because the aim is to provide a framework for impact assessment that could be used to test compliance with law on protection of the environment. The legal requirements are different in different countries, more or less prescriptive, so FASSET is not designed to be a legal instrument, but a framework for impact assessment.

It may also be noted that if you have more than one objective (purpose) you may require to develop more than one model. For example, different assessment endpoints may be required to address different protective objectives, and different endpoints may require different models for assessment.

5.1.2 Endpoints (quantitative and qualitative interpretation…?)

In general, include anything that could be included within a legal requirement, therefore options could include:

- Biodiversity;
- Ecosystems;

- Biological effects;
- Individual dose and effects to fauna and flora, not because these individuals are the point of interest, but because these are the best initial indicators of the health of the populations;
- Gy/d in biota;
- Quality of ecosystems, defined as a list of attributes … (controversial).

There is confusion between what we are protecting and what is the indicator for what is being protected. The view of this group is that doses to organisms should be the calculational endpoint, and then these results should be used as indicators to extrapolate to health populations and ecosystems to develop the decision framework.

FASSET scope does not include protection of the non-biotic environment. If we protect the biota, we have provided sufficient protection of the non-biota?

5.1.3 Philosophy for selection of data

Use 'best estimate' when we have good data, but when we have very poor data, it is necessary to be cautious within the physically reasonable range, and to document the examples of the latter.

5.1.4 Site/System

Various sites and ecosystems to consider:

- Marine, terrestrial, freshwater, estuarine (subsystems is a long list);
- Natural, semi-natural, artificial;
- Geological environment deep underground, groundwater.

Should we also include consideration of cities, urban, industrial? Do we want to protect the rats in the sewer?

It would be useful to include a table of different ecosystems, highlighting what is selected for consideration and what is disregarded at this stage, with reasons, as demonstrated in BIOMASS.

5.1.5 Source terms and modelling interfaces

Different media and entry points should be considered, in addition to whether it is chronic or acute. The physical and chemical form of the radionuclide, as it effects migration and biotic uptake should be taken into account.

The source can be a release into the biosphere (air or water bodies), Bq/y or s (for different time periods), or a standing concentration in air or a water body. Short term acute releases as well as long term releases from facilities that operate for decades, and waste facilities, that operate for the very long term.

Nuclides to study can be categorised by, and should be justified by, including examples of:

- Mobile/immobile;
- Short/intermediate/long half-life (< 1y, < 30y, > 30y);
- Radioactive properties (alpha, beta, gamma).

5.1.6 Time frame

The timeframe should be long enough to address the endpoint of interest, for example, the lifetime of the biota of interest. Acute effects that normally arise for long-term releases should also be considered. It is also important not to forget seasonality.

Is there a separate time frame for the genetic effects?

5.1.7 Societal assumptions

Present environmental conditions, for whatever the environments are.

No intention to address newly evolved species or new adaptations. NB: Bacteria are evolving very quickly…

5.1.8 System identification and justification

The decision tree used in BIOMASS can be applied to FASSET methodology. At first, it should be assumed there is no change in the system, then perhaps consider changes according to the relevant time frame, which may be radionuclide and environmental dependent.

A table of principal components, similar to those in BIOMASS should be used, but reviewed to be more applicable to FASSET. A crude identification of the characteristics can then be extended to become a more detailed description.

5.1.9 System description

BIOMASS experience of the use of interaction matrices to determine the phenomenological interactions between 'habitats' or ecosystems or parts of the system under study suggests that the same technique could be useful in analysing systems in FASSET.

5.1.10 Model development

Radionuclide transfer matrix(ces), as employed in BIOMASS, could also be helpful in tracing how FEPs have been included in the conceptual models for migration and accumulation of radionuclides through the environment.

The BIOMASS FEP-list could be a useful starting point or as an independent checklist for the FEPs of relevance to FASSET model development.

5.2 How would the BIOMASS address the FASSET methodology? (Group 2) – assessment context

FASSET is not an assessment context, but a methodological framework. FASSET is a flexible tool to address environmental impact assessment from different sources over different timeframes. People then use the tool and database to apply in site specific or other context. It is not designed for regulatory compliance, but to show the likely effects on the environment.

It was felt that an important distinction needed to be made between the FASSET project (i.e. justification of the project) and the FASSET framework (i.e. its intended output) when applying the BIOMASS methodology.

The assessment context will change depending on the purpose of the assessment. As it may have to consider both human and non-human effects, the BIOMASS assessment context should be integrated into FASSET.

It was assumed that Problem Formulation is the same as the Assessment Context in the FASSET framework, and then Risk Assessment will provide characterisation to allow management decisions to be made. However, risk characterisation is not well defined, and a description of the procedure of how to do the assessment may be needed. Some issues that arise in problem formulation can be considered in either the problem formulation or the risk assessment stage of the assessment, e.g. spatial considerations, and which reference organisms to consider.

5.2.1 Purpose

FASSET is not a tool to demonstrate only compliance, but to provide an input to decision-makers.

The relevance of the alternative assessment purposes mentioned in BIOMASS were discussed, and it was decided that:

- FASSET could demonstrate compliance with regulatory requirements;
- FASSET could contribute to public confidence and contribute to scientific and policy-maker confidence;
- The FASSET framework may be able to guide research priorities and determine gaps in a safety assessment;
- FASSET may provide guidance to site selection, but its purpose is not aimed at site specific assessment,
- FASSET would include system optimisation, however, the definition of this purpose needs to be clarified;

FASSET can also be used for development of regulatory requirements and as a useful tool when studying remedial action for the management of contaminated land (include in site selection purpose).

5.2.2 Endpoints

Do not need to consider those that are focused on protection of human health, such as individual and collective, risk and dose.

The main endpoint considered is the doses to non-human biota, the reference organism, the individual and ecosystem.

Other endpoints include:

- Contribution and guidance of environmental modelling (related to guiding research purpose).
- Fluxes through the biosphere have not been considered because dispersion is not included. Since dispersion is the same whether human or non-human endpoints are assessed, it was agreed that it could have been useful to include dispersion. On the other hand, since such data already exist, the consortium decided early that inclusion of dispersion would not add anything new to the science of impact assessments.
- Environmental monitoring – related to research priorities.

The list of endpoints can be expanded to include assessments of both individuals and populations of non-human biota.

5.2.3 Philosophy/uncertainties

Estimates of uncertainty or confidence needs to be transparent and clearly demonstrated, because the purpose of an assessment is to reduce uncertainties.

The level of uncertainty depends on how probabilistic or deterministic, and cautious/conservative or realistic the assessment is. How do we know what level of caution we are applying in FASSET? What method should be used to estimate the level of caution? Should safety factors be included?

FASSET will take an equitable approach, almost a realistic approach (worst case is not considered). However, the definition of equitable needs to be redefined from the BIOMASS philosophy to be applicable to the FASSET framework.

Alternative assessment philosophies should be considered but start from scratch not based on the alternative philosophies in BIOMASS, e.g. definition of damage (fits into risk characterisation).

5.2.4 Site/System

Not considered.

5.2.5 Source terms and modelling interfaces

Not considered.

5.2.6 Time frame

Not considered.

5.2.7 Societal assumptions

Not included in FASSET problem formulation. An explanation why it has been excluded is needed.

5.2.8 System identification and justification

FASSET has already identified the seven ecosystems with generic descriptions to represent Europe in the study. The starting point is the seven ecosystems, but it is then possible to apply the BIOMASS system description methodology as a verification procedure to feedback to the generic descriptions of the ecosystems. It can also be applied to more site-specific cases.

The characteristics used in BIOMASS are useful checklist for FASSET. Admit that the best data may not be available because professional ecologists, soil scientists, etc., are not participating; rather it is professional radiation protection experts that are conducting the study.

FASSET is not including all of the BIOMASS biosphere system components, such as human activities and near surface lithostratigraphy. These components can be included in some detail for specific regions.

5.2.9 System description

Use BIOMASS ecosystem community component table for system description to compare and analyse the FASSET ecosystems. After initial justification for the project the descriptions can be also used as a tool.

5.2.10 Model development

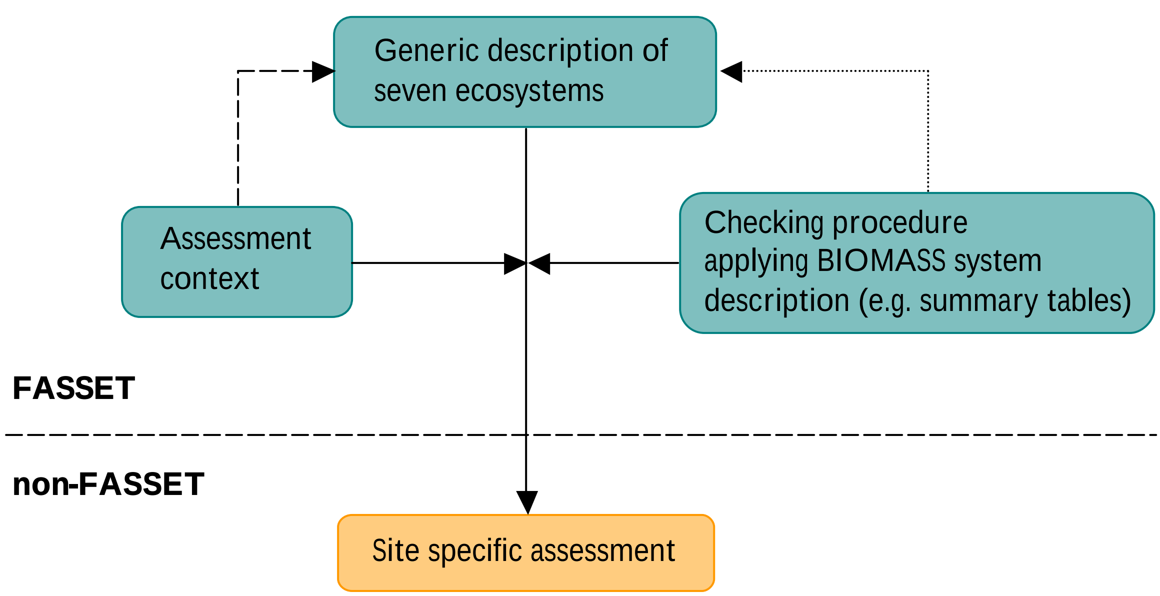
Seven different models are not appropriate for this problem, but it is at least a guide to get a good estimate, e.g. lack of point sources in these models.

5.2.11 Application of data

How will the data be reported?

Is it possible to extract BIOMASS data and incorporate it into FASSET straight away? (All the data employed is included in the technical working documents produced on the BIOMASS beta-2 CD.)

Group 2 illustrated FASSET's system description as:



6. Concluding summary

It was agreed that the meeting was useful and provided clarification of the objectives of FASSET and in particular, WP 4. The discussions about the application of BIOMASS methodology to FASSET were of particular interest, for example, to illustrate how parameters such as FEPs could be of use.

BIOMASS methodology can feed into both the FASSET programme and the framework endpoint. Guidance from BIOMASS (or a step by step approach) would be of benefit to FASSET to ensure all parameters are given due consideration. FASSET will then produce tools and examples to be used, if applicable, in an actual assessment. The BIOMASS approach is good but some changes will be needed to make it more applicable in FASSET.

The concept of devising ‘BIOMASS’ checklists at critical stages of the FASSET assessment was highly encouraged, using key tables. The devised BIOMASS interaction matrices were also seen as helpful, and attempts to integrate them within FASSET was seen as helpful to decision makers. See further Appendix 1.

It was agreed that another meeting of this group of people was not considered necessary, because the BIOMASS documents and authors can be consulted as necessary.

However, in terms of continuation of the FASSET programme, a number of suggestions were made:

- Consider other frameworks and the possibility of holding similar meetings with representatives of organisations involved in those frameworks;
- Consider specific examples (e.g. discharge, disposal, remediation);
- Invite someone to apply the framework in an assessment specific context, i.e. case studies such as impact of discharges – perhaps using EPIC;
- Link FASSET to human radiation standards, for example, use humans as another reference organism (as a large mammal, not including human activity assumptions);
- Perhaps compare FASSET framework for biota with ICRP principles and calculations to check there are no radical differences;
- Inclusion of FASSET methodologies and results in forthcoming IAEA (BIOMASS) and Environment Agency, UK, projects.

7. Bibliography

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Environment Agency, Biosphere Modelling for Solid Radioactive Waste: Overview of BIOMASS Theme 1, R&D Technical Report P3-030/ TR – draft November 2001.

Appendix 1

Overview of BIOMASS methodology and some examples

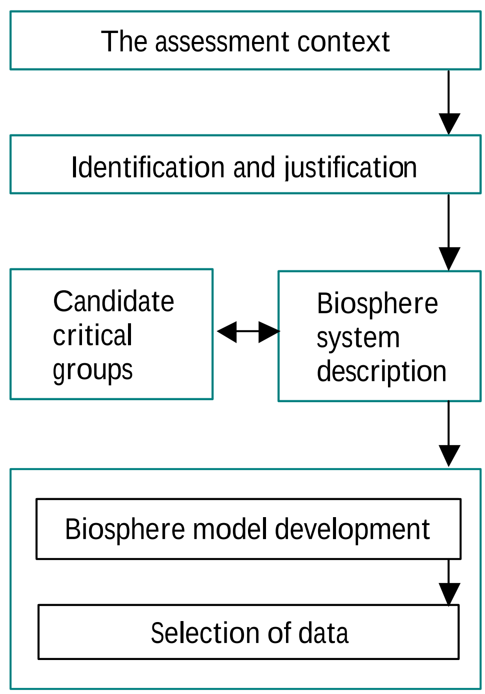

Figure A1:1
BIOMASS methodology.

Appendix 1

Overview of BIOMASS methodology and some examples

Table A1:1
Examples of alternative assessment context components and/or required information.

Assessment context component	Alternatives and/or required information
Assessment purpose	Demonstrate compliance with regulatory requirements/regulatory development Contribute to public confidence Contribute to confidence of policy makers and the scientific community Guide research priorities Proof of concept Guide to site selection and approval at later stages in repository development System optimisation
Assessment endpoint	Individual risk Individual dose Collective doses and risks Doses to non-human biota Modifications to the radiation environment: Distribution/concentration of repository radionuclides in the environment Fluxes into or through parts of the biosphere Estimates of uncertainties or confidence
Assessment philosophy	Cautious Equitable
Repository system	Depth of repository, host geological medium, waste type
Site context	Spatial extent, surface topography, current climate, surface lithology and soil types, fauna and flora, local surface water bodies and near surface aquifers, the need for biosphere change
Source terms and geosphere-biosphere interface	Well Water body Below surface soil Combination of above
Time frames	From closure to 100 years From 100 to 10,000 years From 10,000 to 1,000,000 years Beyond 1,000,000 years
Societal assumptions	Intensive or extensive farming and use of modern technology Simple technology associated with subsistence farming

Table A1:2
Biosphere system component definitions.

Component	Definition	Required information
Climate and atmosphere	Climate is the expression of meteorological parameters over an area.	At a minimum, climate should be described in terms of broad classification of climate states e.g. temperate, boreal. Atmosphere is defined in terms of composition of the air.
Water bodies	Water bodies are the surface and subsurface water masses and may include near-surface aquifers and ice-sheets.	At a minimum, information should be provided as to whether such features are present in the biosphere system.
Human activity	Human activity describes the nature of the communities, their habits, level of technology and degree of subsistence.	Nature of the communities, their habits, level of technology and degree of subsistence.
Biota	Biota is the terrestrial and aquatic plant and animal life in the biosphere system.	A distinction should be made between domestic and wild flora and fauna and between those that are in the food chain and those that are out of the food chain but used by humans for purposes other than food.
Near surface lithostrati-graphy	Near surface lithostratigraphy describes the general characteristics of soils and sediments including both their composition and structure.	Near surface lithostratigraphy includes all weathered material above the bedrock and associated life forms (excluding those predefined under flora). It can include bedrocks if they contain aquifers that are to be considered within the biosphere.
Topography	Topography is the configuration of the earth's surface including its relief and relative positions of natural and man-made features.	Information should be provided concerning the features of the system under consideration and its relief.
Geographical extent	Geographical extent defines the boundaries and/or spatial domain of the biosphere.	At a minimum, the area over which direct contamination of the biosphere may occur should be considered. It should be recognised that extent may change as a function of time.
Location	Location is the position of the biosphere system on the earth's surface.	Information concerning latitude and longitude should be provided for site-specific contexts. For more generic situations, less specific information might be available e.g. coastal, inland, distance from sea, altitude.

Table A1:3
Example Type II screening table (ecosystem community characteristics).

Component	Comment
NET PRIMARY PRODUCTIVITY	Rate at which energy is bound or organic material created by photosynthesis after accounting for respiration per unit area per unit time.
NET SECONDARY PRODUCTIVITY	Net productivity of heterotrophic organisms – animals and saprobes.
BIOMASS/STANDING CROP	Dry weight per unit area. Plants, animals, other organisms.
CROPPING	Rate of removal by humans. Animals and animal products, plants and plant products, other organisms and their products.
POPULATION DYNAMICS	Plants, animals and other organisms.
VEGETATION CANOPIES	Physical structure. Interception of light, water, aerosols, vapours and gases.
PLANT ROOTS	Structure and distribution with depth. Absorption of nutrients and water with depth.
ANIMAL DIETS	Composition and quantity.
BEHAVIOURAL CHARACTERISTICS	The part of the ecosystem in which an animal forages and the time it spends foraging in different parts of the ecosystem, including management aspects where applicable. Animals and other mobile organisms.
CHEMICAL COMPOSITION and CHEMICAL CYCLES	Including sources and sinks. Major and minor nutrients, trace elements.
METABOLISM	Animals, plants and other organisms. *Note: VARIATION WITH SPACE is dealt with under Extent and Heterogeneity) and VARIATION WITH TIME (Diurnal, Seasonal, Annual or other) is dealt in the appropriate descriptive characteristics.*

Appendix 1

Overview of BIOMASS methodology and some examples

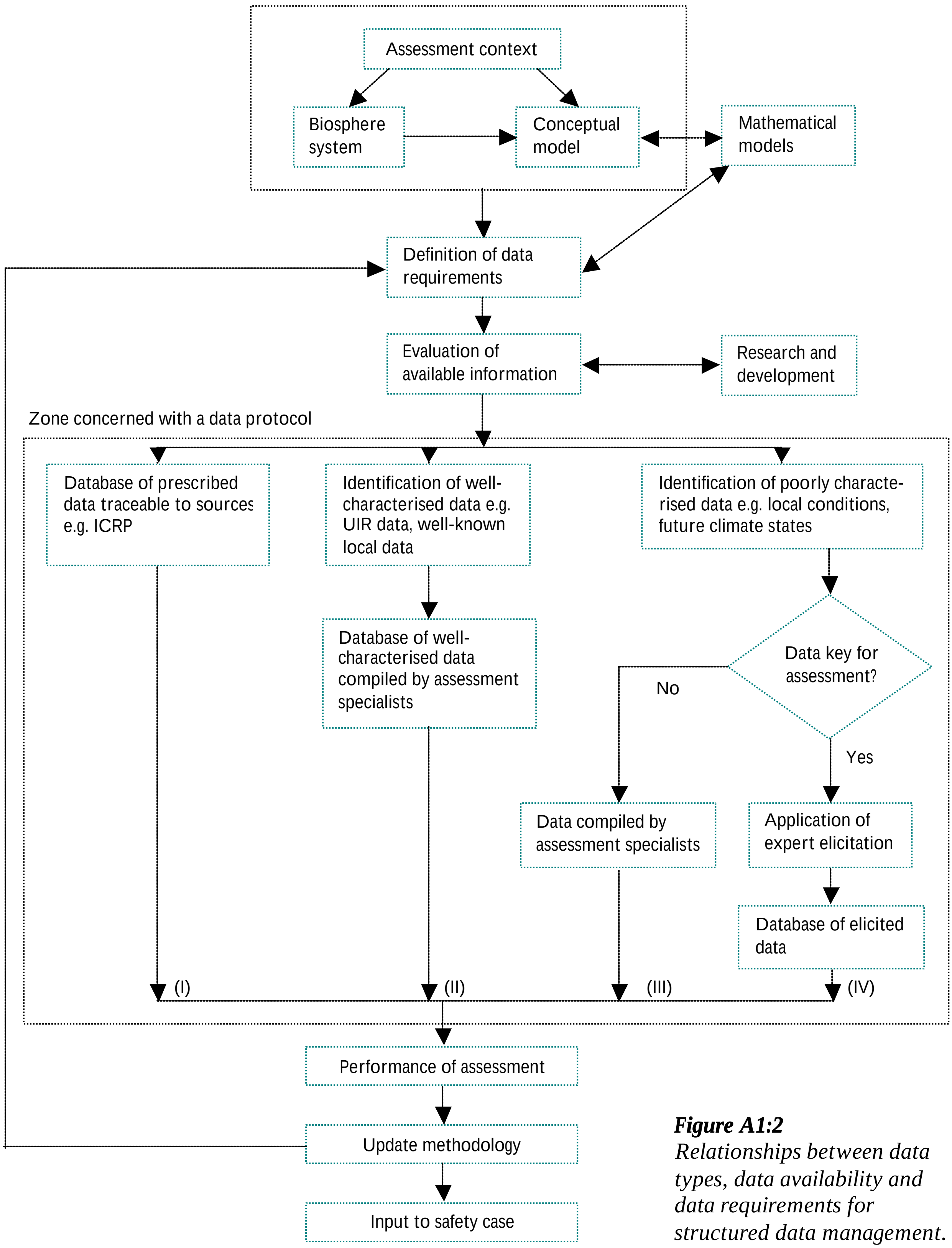

Figure A1:2
Relationships between data types, data availability and data requirements for structured data management.

Appendix 1

Overview of BIOMASS methodology and some examples

Climate		Climate properties in zone of recharge will affect input	Influence on flow boundary conditions in discharge zone	Temperature etc. will affect the volume of water required by the community	May have some influence on water quality but is time invariant	Variability may be relevant factor in determining need for storage	
	Aquifer/ Aqitard	Infiltration rate affected by hydraulic properties of the system	Discharge rate affected by hydraulic properties of the system	Determines quantity and quality of available water at abstraction point	Properties of geological system affect water characteristics		
	Affects flow regime, chemistry etc. in subsurface features	**Water input to aquifer system**					
	Affects flow regime		**Discharge from the aquifer system**	Determines surface water bodies and hence availability of local supplies			
	May perturb natural flow regime			**Abstraction of water from the aquifer for domestic use**	Could cause physical, chemical or biological changes	Can't store or distribute water until it has been abstracted	Drinking water supply comes from abstraction
	Properties of water affect character-ristics of geological system			Physical and chemical changes may affect actual abstraction rate	**Physical and chemical properties of aquifer water**		Water must be potable to be used in drinking water supply
						Water storage and distribution	May affect quality of water supply
							Drinking water supply

Figure A1:3

Interaction matrix representation of the biosphere system for Example 1B.

Radiation Protection in the 21st Century: Ethical, Philosophical and Environmental Issues

Consensus conference on Protection on the Environment[1]

Final Consensus Statement

Introduction

The next decade is likely to bring significant improvement in radiation protection. A number of international bodies are currently considering the development of systems for protection of the environment from ionising radiation. The nuclear industry, authorities and regulators are faced with increasing challenges on the practical application of policy, notably the need to address more widely such values as transparency and stakeholder involvement.

The conference aims were to provide a forum for discussion of current issues in radiation protection and the environment, an input into international developments related to the protection of the environment, and to encourage wider participation in the debate.

In order to discuss these issues, 45 international experts representing various disciplines including Environmental Science, Health Physics, Radioecology, Ethics and Philosophy convened at the Norwegian Academy of Science and Letters, Oslo, 22–25th October 2001. The participants represented a wide spectrum of perspectives bearing on the question of radiation protection of the environment. Participants met in working groups and *in plenum* to develop the main areas of agreement, which are as follows.

Guiding Principles

Humans are an integral part of the environment, and whilst it can be argued that it is ethically justified to regard human dignity and needs as privileged, it is also necessary to provide adequate protection of the environment.

In addition to science, policy making for environmental protection must include social, philosophical, ethical (including the fair distribution of harms/benefits), political and economic considerations. The development of such policy should be conducted in an open, transparent and participatory manner.

The same general principles for protection of the environment should apply to all contaminants.

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[1] A seminar arranged by: the Norwegian Radiation Protection Authority, and the Agricultural University of Norway, on behalf of NKS, in cooperation with IUR.

Appendix 2

Consensus statement (Oslo, Consensus Conference)

Statements

As part of the effort to revise and simplify the current system of radiological protection for humans, there is a need to address specifically radiological protection of the environment.

There are several reasons to protect the environment including ethical values, sustainable development, conservation (species and habitat) and biodiversity.

Our present level of knowledge should allow the development of a system that can be used to logically and transparently assess protection of the environment using appropriate end points. The development of the system ought to identify knowledge gaps and uncertainties that can be used to direct research to improve the system.

The best available technology including consideration of economic costs and environmental benefits should be applied to control any release of radionuclides into the environment in a balanced manner with respect to other insults to the environment.

When a product or activity may cause serious harm to the human population or to the environment, and significant uncertainties exist about the probability of harm, precautionary measures to reduce the potential risk within reasonable cost constraints should be applied. In making such assessments and decisions, an improved mechanism for incorporating developing scientific knowledge needs to be established.

To assess the impact on the environment there is a need to take into account inter alia radiation type, type of organism, and biological endpoints (impact-related). In order to improve the transparency of assessing environmental impacts, the authoritative bodies should consequently give consideration to the development of quantities and units for biota, with the intent to avoid unnecessary complexity.

Appendix 3
Participants

Name	Organisation, country
Larsson, Carl-Magnus	Swedish Radiation Protection Authority (SSI), Sweden
Avila, Rodolfo	Swedish Radiation Protection Authority (SSI), Sweden
Moberg, Leif	Swedish Radiation Protection Authority (SSI), Sweden
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Calvez, Marianne	ANDRA – DS/BE, France
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Gilek, Michael	Stockholm University, Sweden
Kumblad, Linda	Stockholm University, Sweden
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Smith, Graham	Enviros Quantisci, UK
Kerrigan, Emma	Enviros Quantisci, UK
Proehl, Gerhard	Institute for Radiation Protection (GSF), Germany
Robinson, Carol	IAEA, Austria
Jones, Celia	Kemakta, Sweden
Sjöblom, Kirsti-Liisa	Radiation and Nuclear Safety Authority (STUK), Finland
Kautsky, Ulrik	SKB, Sweden